

# 1 INTERNALLY DISPOSED LINEAR FASTENER SYSTEM

## 2 3 FIELD OF THE INVENTION

4 The present invention relates to an internally disposed  
5 linear fastener system. More specifically, to a linear  
6 engaging set screw system utilizing an outwardly expandable set  
7 screw in combination with an internal linear traversable sleeve  
8 member. The inner sleeve member is capable of rapid linear  
9 traversing engagement and disengagement to form a versatile and  
10 effective vibration resistant fastener system which may be used  
11 to reproducibly interconnect disparate components.

## 12 13 BACKGROUND OF THE INVENTION

14 In general, a fastener is any device used to connect or  
15 join two or more components to create an assembly. In the  
16 field of manufacturing there are numerous assembly processes  
17 requiring individual components to be joined with fasteners to  
18 create an assembled product. Most of these processes,  
19 requiring fixations of one component in relation to another,  
20 are currently performed using threaded fasteners for  
21 connections. The most common threaded fasteners are referred  
22 to by many names, among them: bolts, screws, nuts, studs, lag  
23 screws, and set screws.

24 When a bolt is used to clamp two parts together, the

1 force exerted between the parts is generally referred to as the  
2 clamping load. A clamping load is produced by exerting a  
3 rotational torque on a threaded fastener that is converted to  
4 linear travel via the helical threads. These forces keep the  
5 threads of the mating parts in intimate contact and decrease  
6 the probability of the fastener loosening in service. However,  
7 it is well known that threaded fasteners loosen over time when  
8 the part to which the fastener is affixed is subjected to shock  
9 or vibration. This is particularly true of threaded type  
10 fasteners used on devices with moving parts or in conjunction  
11 with motors or vehicles. To prevent this loosening, locking  
12 fasteners, lock washers, plastic inserts in the nut or bolt,  
13 adhesives, cotter pins, locking tabs, etc., are available to  
14 hold a threaded fastener in place until it is purposefully  
15 loosened. Most of these locking devices cooperate in one way  
16 or another with the head of the fastener.

17 However, in many fastening applications a typical bolt  
18 with a head cannot be used; for example, in situations where a  
19 head would limit the distance the bolt could be tightened into  
20 an aperture or where a protruding head on a moving or rotating  
21 part could damage equipment or personnel. In these situations  
22 a set screw is typically used in place of a bolt. Devices such  
23 as lock washers cannot be used to hold headless fasteners in  
24 place and thus they are especially prone to loosening. A

1 typical application for set screws is securing collars to  
2 shafts. In these applications, a set screw is tightened within  
3 a threaded aperture in a collar to apply pressure to the side  
4 of the shaft. Because the set screws are subjected to shock  
5 each time the shaft is started and vibration while the shaft is  
6 rotating, the set screws often loosen over time increasing the  
7 required machinery maintenance.

8 In the past, alternate methods for locking a set screw to  
9 a part, thereby preventing the screw from loosening have been  
10 employed. These methods include staking the set screw to the  
11 part, using plastic or elastomeric inserts to bind the threads,  
12 and the use of thread locking adhesives to adhere the threads  
13 of the set screw to the threads of the part. Each of these  
14 solutions has inherent problems associated therewith. Staking  
15 the set screw to the part requires prick punching the boundary  
16 between the set screw and the part. This method creates an  
17 unsightly surface on the part and, over multiple lockings,  
18 damages both the set screw and the part. Plastic inserts  
19 require additional and costly manufacturing processes and  
20 require the fastener to be replaced after one use. Using an  
21 adhesive substance with the set screw can destroy the set screw  
22 and clog threads in the part.

23 With reference to the field of orthopedic surgery there  
24 are various procedures which require insertion of an anchor,

1 pin, peg, screw or cage into skeletal bone for the purpose of  
2 correcting anatomical defects. Related orthopedic procedures  
3 include reconstruction, such as the formation of artificial  
4 joints and teeth. All of these procedures, requiring fixations  
5 of an appliance in the bone, are currently performed using  
6 threaded connections between the components. For example, in  
7 many spinal corrections, pedicle screws are placed in the  
8 vertebrae to support cages or plates for fixing spatial  
9 orientation. The connection of the screws to the ancillary  
10 devices usually require concomitant application of torque to  
11 the vertebrae through the pedicle screw. Similarly, in placing  
12 artificial teeth on screw-like pegs inserted in the jaw bone,  
13 a particular degree of torque may be applied in the course of  
14 fitting of the teeth. Thereafter, attachment of auxiliary  
15 devices to the screw-like pegs, using fasteners that require  
16 torque, may be detrimental to the integrity of the pre-torqued  
17 screws securement within the bone.

18 Accordingly, what is lacking in the prior art is a cost  
19 effective internally disposed linear fastening system,  
20 particularly a locking set screw system capable of linear  
21 engagement+. The set screw locking system should achieve  
22 objectives such as providing improved manufacturing and  
23 assembly efficiency, effective reliable performance, corrosion  
24 resistance, and torqueless locking assembly. The system should

1 include packaging flexibility for installation on various  
2 products, including retrofitting existing product  
3 configurations with minimal modification of the original  
4 product.

#### 5 DESCRIPTION OF THE PRIOR ART

6 A number of prior art threaded locking fasteners exist for  
7 attaching components together to form an assembly. Most of  
8 these fasteners are designed to lock when the end of the  
9 fastener contacts a surface at the end of an aperture. For  
10 example, U.S. Pat. No. 2,900,863 teaches a two piece expansion  
11 bolt with a cylindrical shank and an expansion plug. When the  
12 shank of this fastener is driven into an aperture, the  
13 expansion plug acts to expand and wedge the lower end of the  
14 fastener against the walls of the aperture. The wedged lower  
15 end of the bolt prevents the bolt from turning when a  
16 cooperating nut is threaded onto the upper end of the bolt.  
17 Some disadvantages of this prior art invention are that the  
18 fastener is not easily removable from the aperture and the bolt  
19 is not designed for use in a threaded aperture.

20 Two other locking fastener designs are disclosed by U.S.  
21 Pat. Nos. 4,411,570 and 4,976,577. These patents teach hollow,  
22 threaded, locking bolts constructed to cooperate with a  
23 threaded aperture. Within the hollow center portion of the  
24 bolt is a plunger that may be driven through the center of the

1 fastener to expand the lower end of the fastener outwardly  
2 against the sides of the threaded aperture. The disadvantage  
3 of these inventions is that they are difficult to remove. In  
4 addition they require small diameter and precisely machined  
5 internal bores through the center of the bolt. The small bores  
6 are difficult to machine and add significant cost to the  
7 fasteners.

8 It is also known in the prior art to provide various  
9 fasteners capable of partial linear and partial rotational  
10 engagement. These fasteners generally feature radially  
11 inwardly or outwardly biased arcuate segments mounted to engage  
12 the threads of a bolt, nut or other threaded member. The  
13 threaded segments are generally movably mounted within a casing  
14 or around a shaft and resiliently urged inwardly or outwardly.  
15 Typically the devices are provided with axially spaced apart  
16 radially inwardly directed surfaces of revolution, such as  
17 frustoconical surfaces, extending at a common acute angle to  
18 the axis of the fastener. In this manner the fasteners and  
19 couplings may be secured by merely pushing the threaded  
20 components together, thereafter final tightening is  
21 accomplished by rotation of the fasteners.

22 U.S. Patent No. 5,788,443 teaches a male coupling device  
23 featuring movably mounted threaded members which are capable of  
24 rapid engagement and disengagement with respect to the

1 stationary threads of a female coupling device. The male  
2 coupling device includes a handled shaft having a plurality of  
3 threaded segments surrounding the shaft. A sleeve is mounted  
4 to move relative to the handle to move the threaded segments  
5 inwardly and outwardly to effectively vary the diameter of the  
6 assembled threaded elements.

7 U.S. Patent No. 5,244,323 teaches a threaded, locking set  
8 screw having a threaded body, a resilient expansion plug, and  
9 a retaining wedge. The threaded body has a tapered cavity at  
10 its bottom end. The expansion plug and retaining wedge are  
11 aligned and inserted into the cavity in the bottom portion of  
12 the body. The base of the plug extends outwardly from the  
13 cavity, and the plug is held in place by a force fit between  
14 the wedge and a retaining slot in the body. When the set screw  
15 is tightened against a part, the plug is forced into the  
16 cavity. Because of a locking taper between the plug and the  
17 cavity, the plug exerts an outward force on the inner surface  
18 of the cavity causing the set screw body to expand radially,  
19 thus, locking the set screw in place.

20 While the prior art devices allow the fastener to engage  
21 the sides of an aperture for locking purposes, these devices  
22 require extensive machining of thin sections and require  
23 difficult manufacturing processes. This combination results in  
24 high production cost and weak finished components. In

1 addition, the designs of the prior art devices do not lend  
2 themselves to traditional fastener manufacturing techniques,  
3 e.g. cold forming -a manufacturing technique which is known to  
4 result in much stronger and more reliable fasteners, thread  
5 rollers, pointers, nut tappers, slotters, shavers etc., adding  
6 to the high manufacturing cost and reducing the strength of the  
7 fasteners.

8       Thus in one illustrated embodiment, the present invention  
9 teaches a linear locking set screw system that includes a  
10 standard diameter threaded set screw and an inner compressing  
11 ring member that is capable of rapid linear actuated locking  
12 engagement and/or disengagement. In a second illustrated  
13 embodiment the present invention teaches a linear locking set  
14 screw that is capable of applying precise secondary clamping  
15 force to disparate assembled components without requiring  
16 rotation of the fastening members.



1     **SUMMARY OF THE INVENTION**

2             The present invention provides a linear locking set screw  
3     system capable of rapid linear engagement and disengagement.  
4     More specifically, the system utilizes a threaded outwardly  
5     expandable set screw and an expander member which are  
6     constructed and arranged to thread easily into a threaded  
7     aperture while in a first release position and can thereafter  
8     be securely locked in place and/or provide a secondary clamping  
9     force in a second engaged position.

10            In a first embodiment, the set screw member is constructed  
11    and arranged with a standard sized outer threaded surface and  
12    an inner cavity including a driving and a frustaconical  
13    surface, the expander member being constructed and arranged  
14    with an inner threaded surface and an outer frustaconical  
15    surface preferably conjugate in shape with respect to the inner  
16    frustaconical surface of the set screw member. In operation  
17    the set screw body is threaded into a threaded aperture and  
18    tightened to a desired torque. Thereafter, the set screw body  
19    is locked in place by traversing the expander member in a  
20    linear fashion along the axis of rotation of the set screw, so  
21    as to insert said expander member within the inner cavity in  
22    the upper portion of the set screw body, thereby utilizing the  
23    frustaconical surfaces to expand the set screw body and place

1 a compressive load on the expander member to expand the set  
2 screw body to grip the inner threaded aperture surface.

3 In a second embodiment, the set screw body member is  
4 constructed and arranged with an undersized diameter threaded  
5 surface and an inner cavity including a driving and a  
6 frustaconical surface, the expander member being constructed  
7 and arranged with an inner threaded surface and an outer  
8 frustaconical surface preferably conjugate in shape with  
9 respect to the inner frustaconical surface of the set screw  
10 body member. In operation the set screw body is threaded into  
11 a threaded aperture until the distal end of the set screw  
12 contacts the desired surface. The expander member is inserted  
13 in a linear fashion into the cavity in the upper portion of the  
14 set screw body, thereby utilizing the frustaconical surfaces to  
15 expand the set screw body and place a compressive load on the  
16 expander member to expand the set screw outwardly. As the set  
17 screw body is expanded the threaded surfaces cooperate in a  
18 helical or circular ramping fashion to force the set screw  
19 downward, thereby causing a secondary clamping load between the  
20 components.

21 In this manner, the locking set screw system is capable of  
22 providing a precise, secure, and reproducible connection  
23 between multiple components. The connection also allows full  
24 thread engagement and a locking connection without the need for

1 plastic inserts or adhesives. When compared to traditional  
2 threaded set screws, the dual frustaconical compression  
3 surfaces allow very precise clamping loads to be applied to the  
4 assembled components with or without application of rotational  
5 torque. Prior art designs require torque wrenches to apply  
6 measured clamping loads to fasteners. Linear expansion of the  
7 set screw member eliminates torque variations as seen in the  
8 prior art due to surface finish, lubrication and thread  
9 engagement to achieve a precise clamping load.

10 Accordingly, it is a primary objective of the present  
11 invention to provide an internally disposed linear fastener  
12 system capable of precisely and reproducibly securing multiple  
13 components into a single assembly without necessitating the  
14 concomitant application of rotational torque to previously  
15 created sub-assemblies.

16 An additional objective of the present invention is to  
17 provide a fastener system capable of precise and reproducible  
18 linear engagement and disengagement.

19 It is a further objective of the present invention to  
20 provide a fastener system capable of providing precise and  
21 reproducible linear engagement to internally threaded surfaces  
22 and the like.

23 A still further objective of the present invention is to  
24 provide a fastener system capable of providing precise and

1     reproducible linear engagement to internal circular ramps and  
2     the like.

3             Yet another objective of the present invention is to  
4     provide a fastener system suited for automated manufacturing  
5     and assembly.

6             Still yet another objective of the present invention is to  
7     provide a fastener system that enables close spacing of the  
8     assembled components and does not require wrench clearances.

9             Yet a further objective of the instant invention is to  
10    teach the use of linear fasteners for modular implants having  
11    an element anchored in bone and a support element for ancillary  
12    devices, each with a cooperating coupling component adapted to  
13    be secured together without rotational torque forces.

14            An additional objective of the instant invention to teach  
15    a linear coupling device for medical implants with a pressure  
16    limiting element.

17            Other objects and advantages of this invention will become  
18    apparent from the following description taken in conjunction  
19    with the accompanying drawings wherein are set forth, by way of  
20    illustration and example, certain embodiments of this  
21    invention.     The drawings constitute a part of this  
22    specification and include exemplary embodiments of the present  
23    invention and illustrate various objects and features thereof.  
24

1 BRIEF DESCRIPTION OF THE FIGURES

2 FIG. 1 shows a perspective view of one embodiment of the  
3 instant invention being utilized to secure a shaft within a  
4 component;

5 FIG. 2 shows a section view along line 1-1 of the  
6 embodiment illustrated in FIG. 1, illustrating the set screw  
7 body member with the expander member in the engaged position;

8 FIG. 3 shows a perspective view of one embodiment of the  
9 set screw body member of this invention;

10 FIG. 4 shows a perspective view of one embodiment of the  
11 expander member of this invention;

12 FIG. 5 shows a perspective view of one embodiment of the  
13 instant invention being utilized to secure an alignment rod  
14 within a lateral support of a pedicle screw;

15 FIG. 6 shows a section view along lines 2-2 of the  
16 embodiment illustrated in FIG. 5, illustrating the set screw  
17 body member with the expander member in the engaged position;

18 FIG. 7 shows a perspective view of one embodiment of the  
19 set screw body member of this invention;

20 FIG. 8 shows a perspective view of one embodiment of the  
21 expander member of this invention;

22 FIG. 9 shows a partial cross sectional view of one  
23 embodiment of this invention, illustrating the relative motions

1     that result in the secondary clamping force during assembly of  
2     the instant invention;  
3

1 DETAILED DESCRIPTION OF THE INVENTION

2 Although the invention is described in terms of a  
3 preferred specific embodiment, it will be readily apparent to  
4 those skilled in this art that various modifications,  
5 rearrangements and substitutions can be made without departing  
6 from the spirit of the invention. The scope of the invention  
7 is defined by the claims appended hereto.

8 Referring to FIGS. 1 and 2, the linear engaging headless  
9 set screw 10 utilized to secure the shaft 14 within a machinery  
10 component 15 is a representation of the general utility of the  
11 present invention. The linear engaging headless set screw 10  
12 of the instant invention generally comprises an axially aligned  
13 body member 11 and expander member 12.

14 Referring to FIGS. 3 and 7, the body member 11 comprises  
15 a generally cylindrical outer surface 16 having a first end 18  
16 and a second end 20. The body member 11 may be constructed of  
17 materials well known in the art which may include but should  
18 not be limited to steel, bronze, brass, copper, aluminum,  
19 plastic, ceramic, or rubber, as well as suitable combinations  
20 thereof. The first end 18 of the body member 11 includes a  
21 cavity 22 and a driving means. In the preferred embodiment the  
22 cavity 22 includes an engaging surface 26, the engaging surface  
23 tapering inwardly beginning at the first end and extending  
24 toward the second end of the body member 11. In the preferred

1 embodiment the engaging surface includes a self-holding taper  
2 such as a Morse, Brown & Sharpe (Jarno), American National  
3 Standard Machine Taper (Jacobs), British Standard Tapers and  
4 the like all well known in the art. Alternatively, self-  
5 releasing tapers well known in the art suitable for  
6 circumferential expansion of the upper portion 28 of the body  
7 member 11 may be used. The driving means comprises at least  
8 one and preferably a plurality of driving surfaces 24. In the  
9 preferred embodiment the driving surfaces 24 are constructed  
10 and arranged to cooperate with a standard hex wrench (not  
11 shown). However, it should be noted that other spline and slot  
12 type driving sockets well known in the art suitable for  
13 inserting and removing threaded fasteners may also be used.  
14 The second end 20 of the set screw body is constructed and  
15 arranged as a clamping surface 30 (FIG. 2). The clamping  
16 surface 30 in the preferred embodiment is a flat point.  
17 However, it should be noted that other set screw points (not  
18 shown) such as a dog point, half dog point, cup point, oval  
19 point, cone point or knurled point, all well known in the art,  
20 may be utilized with the instant invention. The body member 11  
21 preferably includes a radially projecting means for engaging  
22 the inner surface of an aperture illustrated herein as  
23 outwardly and circumferentially extending rib(s) 32 (FIG. 2)  
24 positioned about a central axis. Each circumferentially



1 extending rib 32 being constructed with a first ramp surface 36  
2 to allow the set screw member to slide into the aperture and a  
3 second ramp surface 38 to allow a second clamping force as the  
4 engagement of expander 12 causes radial expansion of the set  
5 screw body 11. In further embodiments, the outer gripping  
6 surface may also include any number of surface finishes well  
7 known in the art to enhance the gripping action between the set  
8 screw body and cooperating aperture, including but not limited  
9 to, threads, knurling, snap ring grooves, generally smooth  
10 and/or tapers, or suitable combinations thereof, as well as  
11 other surfaces suitable for providing adequate grip between the  
12 set screw body 11 and the inner surface of an aperture 40 to  
13 secure an assembly. The upper portion 28 of the body 11  
14 includes at least one generally vertical slot 48 extending from  
15 the upper portion 28 of the set screw body 11 toward the second  
16 end 30. The vertical slot(s) 48 facilitates translation of the  
17 radial and outward forces created upon insertion of the  
18 expander member within the upper portion 28 of the body member  
19 11 into a relatively uniform circumferential expansion of said  
20 body member 11.

21 Referring to FIGS. 4 and 8, the expander member 12  
22 comprises a body 46 having a first end 42 and a second end 44.  
23 The outer surface 48 in the preferred embodiment having a  
24 frustaconical taper generally conjugate to the taper within the

1 set screw body cavity 22. In the preferred embodiment the  
2 outer surface taper 48 is a self-holding taper such as a Morse,  
3 Brown & Sharpe (Jarno), American National Standard Machine  
4 Taper (Jacobs), British Standard Tapers or the like all well  
5 known in the art. Alternatively, other tapers well known in  
6 the art suitable for circumferential expansion of the upper  
7 portion 28 of the set screw body 11 may be used. The expander  
8 member 12 may include an inner bore 50 extending inwardly from  
9 said first end of said expander member along a longitudinal  
10 centerline for gripping the expander member 12 for extraction  
11 from the set screw body 11. The inner surface may also include  
12 a driving means such as, but not limited to threads, sockets or  
13 slots for engagement with wrenches, screwdrivers and/or an  
14 extractor (not shown) used to remove or disconnect the  
15 coupling. Alternatively, the expander member 12 may include a  
16 flange 52 (FIGS. 6 and 8) at its second end 44, the flange 52  
17 having a larger diameter than the second end 44 of the expander  
18 member 12 to remove or disconnect the coupling. In a further  
19 alternative embodiment the outer surface of the expander body  
20 includes connection means (not shown) which allow the set screw  
21 member and the expander member to be interlocked into a  
22 coaxially aligned sub-assembly prior to insertion into an  
23 aperture. Suitable connection means include adhesives, living  
24 hinges and the like.

1 Referring to FIGS. 5 and 6, the linear engaging headless  
2 set screw 10 is illustrated securing an alignment rod 60  
3 within a lateral support 62 of a pedicle screw assembly 64  
4 illustrating the particularly low profile constructions  
5 possible with the instant invention.

6 Referring to FIG. 9, The assembly of one embodiment of the  
7 instant invention and relative motion in relation thereto is  
8 illustrated. The set screw body 11 is loosely threaded into an  
9 aperture 66. The set screw body 11 is tightened to a first  
10 torque. Thereafter the first end 42 of the expander member 12  
11 is inserted into the set screw cavity 22. As the expander  
12 member 12 is linearly traversed further into the cavity, the  
13 set screw body 11 is expanded circumferentially. As the set  
14 screw body 11 is expanded, the threaded surfaces cooperate in  
15 a helical or circular ramping fashion to force the set screw  
16 downward, thereby causing a secondary clamping load between the  
17 components. Once the body member 11 is expanded and outer  
18 surface 16 of the body member engages the inner surface 40 of  
19 the aperture a connection is created that is resistant to  
20 undesired loosening. In this manner, the locking set screw  
21 system 10 is capable of providing a precise, secure, and  
22 reproducible connection between multiple components. The  
23 connection also allows full thread engagement and a locking  
24 connection without the need for plastic inserts or adhesives.

1           In an alternative embodiment the set screw body 11 is  
2   inserted into the aperture 66 and tightened to a desired  
3   torque. The expander member 12 is inserted into the cavity 22  
4   in the first end 18 of the set screw body. As the expander  
5   member 12 is pressed into the body cavity 22, the body is  
6   expanded circumferentially locking the outer surface 16 of the  
7   set screw body 11 against the walls of the aperture 66. Once  
8   the body member is expanded and an outer surface of the body  
9   member engages the inner surface of the aperture a connection  
10   is created that is resistant to undesired loosening.

11           When compared to traditional threaded set screws, the dual  
12   frustaconical compression surfaces utilized in the instant  
13   invention allow very precise clamping loads to be applied to  
14   the assembled components with or without application of  
15   rotational torque. Linear expansion of the set screw member  
16   body eliminates torque variations as seen in the prior art due  
17   to surface finish, lubrication and thread engagement to achieve  
18   a precise clamping load.

19           All patents and publications mentioned in this  
20   specification are indicative of the levels of those skilled in  
21   the art to which the invention pertains. All patents and  
22   publications are herein incorporated by reference to the same  
23   extent as if each individual publication was specifically and  
24   individually indicated to be incorporated by reference.

1           It is to be understood that while a certain form of the  
2 invention is illustrated, it is not to be limited to the  
3 specific form or arrangement herein described and shown. It  
4 will be apparent to those skilled in the art that various  
5 changes may be made without departing from the scope of the  
6 invention and the invention is not to be considered limited to  
7 what is shown and described in the specification.

8           One skilled in the art will readily appreciate that the  
9 present invention is well adapted to carry out the objectives  
10 and obtain the ends and advantages mentioned, as well as those  
11 inherent therein. The embodiments, methods, procedures and  
12 techniques described herein are presently representative of the  
13 preferred embodiments, are intended to be exemplary and are not  
14 intended as limitations on the scope. Changes therein and other  
15 uses will occur to those skilled in the art which are  
16 encompassed within the spirit of the invention and are defined  
17 by the scope of the appended claims. Although the invention  
18 has been described in connection with specific preferred  
19 embodiments, it should be understood that the invention as  
20 claimed should not be unduly limited to such specific  
21 embodiments. Indeed, various modifications of the described  
22 modes for carrying out the invention which are obvious to those  
23 skilled in the art are intended to be within the scope of the  
24 following claims.